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RESTRICTING DUST EMISSION FROM FORCED-DRAFT BOILER INSTALLATIONS, CAPACITY 30 TON/HR AND OVER, HARD COAL-DUST FIRED WITH DRY ASH REMOVAL

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RESTRICTING DUST EMISSION FROM FORCED-DRAFT BOILER INSTALLATIONS, CAPACITY 30 TON/HR AND OVER, HARD COAL-DUST FIRED WITH DRY ASH REMOVAL

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VDI-Kommission Reinhaltung der Luft

VDI-Handbuch Reinhaltung der Luft

Foreword

This is one of several dozen VDI Clean Air Committee specifications on air purification which the Division of Air Pollution of the U.S. Public Health Service has obtained permission to translate, publish, and distribute in limited quantity. A complete list of the VDI publications being published by the Division of Air Pollution appears on the inside back cover. Because the VDI Committee from time to time revises these specifications, this and other publications in the series may be superseded by later publications.

The VDI Clean Air Committee specifications are compiled by trade or professional associations and published by the Committee. The Committee has neither official status nor regulatory authority, although West German governmental agencies participate in its activities. Air quality specifications published by the Committee are therefore advisory, rather than regulatory. They may however later be adopted by West German governmental authorities.

The English translations were done by the Joint Publications Research Service of the Office of Technical Services, U.S. Department of Commerce. It should be borne in mind that various terms literally taken from the German do not have the same connotation in English; for example, the word "standard" frequently appears where the word "criteria" might better reflect the comparable American meaning, since in this country "standard" is generally meant to imply a legally enforceable value, while "criteria" usually means a recommended value upon which standards may be based.

The publication and distribution of these translations by the Public Health Service constitutes neither endorsement of the specifications nor of the air quality or emission limitations recommended in them. We believe that they contain much useful information that would otherwise not be available to non-readers of German and for this reason have made them available to workers in the air pollution field in the United States.

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VDI No. 2092, November 1961

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VDI COMMITTEE FOR AIR PURIFICATION

The VDI Committee for Air Purification is composed of experts in all fields of importance for air purification. These experts collaborate with the Committee on their own responsibility and without compensation and are proposed for the Committee by the following societies and institutions:

German Society for Hygiene and Microbiology
German Society for Oil and Coal Chemistry
German Society of Gas and Water Experts
German Meteorological Services
Society of German Chemists
Society of German Iron Mine and Steel Mill Experts
Association of Anthracite Mines
Technical Inspection Associations
Society of German Steel Mill Experts
Society of German Foundry Experts
VDI Trade Section on Dust Technology
Association of Steam Boiler Owners

Scientists from Universities and Institutes in Biology, Chemistry, Forestry and Agriculture, Human and Veterinary Medicine, Metallurgy, Physics, and Technology
Research Institute of the Cement Industry

Federation of German Industry (Chemical Industry, Oil Industry, Automobile Industry, etc.)
German Federal Railroads
Federation of German Farmers
Federation of Community Associations
Settlement Federation of the Ruhr-Coal District
Competent Federal and State Ministries
Institute for Water, Soil, and Air Hygiene of the Federal Public Health Service
Public Inspection Services

INTRODUCTION

The VDI Specifications on Air Purification are divided into the following groups:

1. Permissible Immission Concentration (PIC-values)
2. Calculation of the Distribution of Dust and Gas
3. Restriction of the Emission of Dust and Gas
4. Dust and Gas Measuring Techniques.

In the evaluation of problems of air pollution, the inner relation of these four groups of specifications must be considered.

The present specifications concern the occurrence and reduction of dust in steam-generating installations with a capacity of over 30 ton/hr.

It is the purpose of the specifications:

to describe parts of the installation in which dust occurs;
to characterize the influences leading to the formation of dust;
to point out measures for the selection of suitable dust-removal installations and their maintenance;
to establish guide lines for the restriction of dust emission by new installations.

The measures recommended in the specifications take into account the most recent technical findings. As the latter are further developed, the specifications will be adapted to them.

VDI Specifications No. 2299 (in preparation) is applicable to the restriction of the emission of gas, including sulphur dioxide, by steam generating installations.

1. Technology

Guide Values for Standard Furnace Installations:

In any furnace installation, dust is created which consists of fly-ash and cinders (incombustibles). The grain size of the dust can be very fine when firing coal dust and depends on the grinding. A small part of the ash introduced into the furnace fuses in combustion and is removed as combustion-chamber ash. Part of the coarser dust becomes deposited in the boiler flues. The dimensions of the dust-removal installation and/or the efficiency rate to be selected is influenced by the fusion of the ash during combustion and the precipitation in the boiler flues (2).

With suitable design and proper operation of the furnace installation, black smoke (soot) should not occur (Cf. VDI Specifications No. 2300 on Restricting Emission of Dust from Steam Generators, Capacity 10 tons/hr and Less; in preparation).

The following indicates average values but individual steam generators have been built for capacities and conditions which differ essentially from the data below.

Table 1

Utilization of Hard-Coal Dust with Dry Ash Remover	Steam Generators, Capacity 30-600 ton/hr and over
Fuel range	Lean coal to caking gas coal including all types of coal as well as medium classification and slurry
Grain classification	0-30 mm
Volatile components (in relation to water-and ash-free coal	8-40%
Ash content (in relation to water-free coal; 2, 3).	Up to 45%, generally 5-20% (high values for gas-rich coal).

(continued)

(continuation of Table 1)

Utilisation of Hard-Coal Dust with Dry Ash Remover	Steam Generators, Capacity 30-600 ton/hr and over
Sulphur content	1.0-1.5%; for medium classification and slurry, 2-3%.
Water content	5-30%, generally 5-10%.
Calorific value	7,500-3,200 kcal/kg
Combustion chamber load (4)	130,000-250,000 kcal/m^3/hr
Secondary air (4)	20-90% of combustion air; depending on method of combustion, fuel and type of furnace; pressure 250-800 mm water and higher.
Preheating of air (4)	300-400° C, depending on coal and grinding equipment
<u>Flue Gases at Smoke Box</u>	
Temperature	130-200° C
CO_2 - content	13-15%
Specific flue gas volume (average values; 5)	At calorific values of 7,500 5,000 3,200 respectively 10.2 7.4 5.4 Nm^3/kg of coal.
Fly-ash content in raw gas (in relation to moist gas)	Up to 70 g/Nm^3 and over, depending on ash content of fuel, incombustibles in fly-ash and method of operation.
Grain classification of raw gas dust	Depending on type of fuel, grind, method of combustion, furnace operation, with or without fly-ash recirculation (Cf. Fig. 1).
SO_2 - content in raw gas	Cf. VDI Specifications No. 2299 (in preparation).
Ash fusion in combustion chamber and boiler flues (2).	10-20% of total ash introduced with fuel.

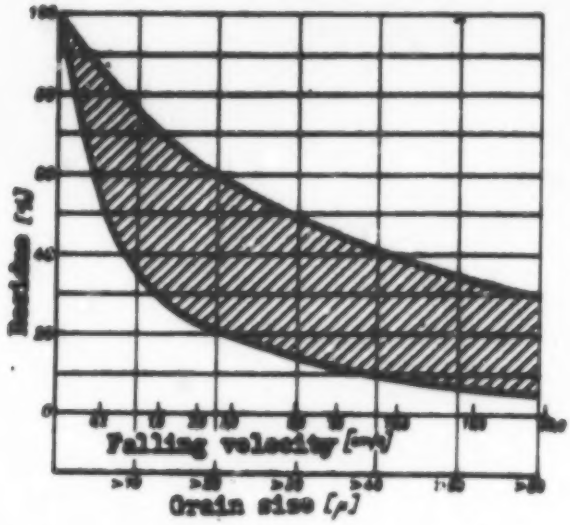


Figure 1. Classification Range of Dust in Raw Gas from Hard Coal-Dust Furnaces with Dry Ash Removal (From the Investigations of the TUV Essen: 1).

(Primary measurements are the falling velocity in air; the grain sizes so calculated are valid only for spherical particles of the specific unit weight $\gamma = 2$ g/cm^3.

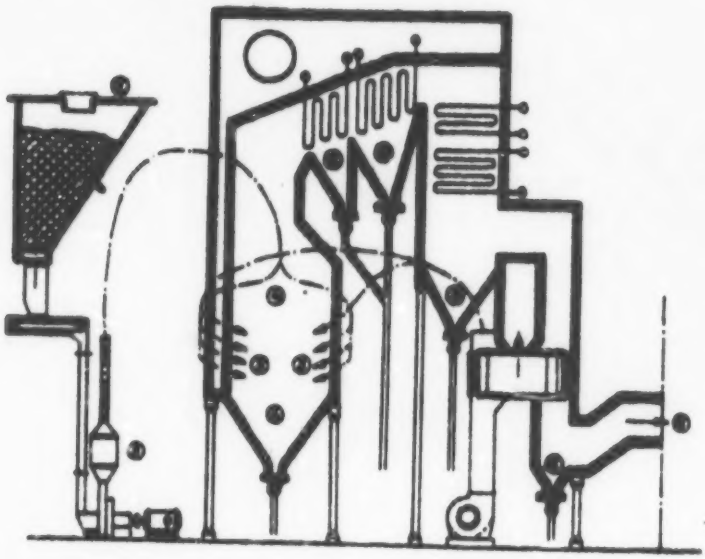


Figure 2. Diagram of Steam Generator with Hard Coal-Dust Furnace and Dry Ash Removal

Numbers designate points influencing formation of dust.

1 - Coal
2 - Grinding
3 - Burner and combustion in combustion chamber
4 - Combustion chamber
5 - Secondary heating surfaces and dust collector
6 - Dust-separator installation.

2. Reduction of Dust Emission

2.1 Influences within Steam Generators

Table 2

Point of Origin	In regard to the formation of fly-ash, the conditions listed below act:	
	Increasing	Reducing
Coal Fig. 2 ①	High ash content; low content of volatile components.	Low ash content; favorable ash characteristics for precipitation.
Grind Fig. 2 ②	Grind too coarse (formation of cinder; grind too fine (increased share of fine dust and less precipitation).	Grind suitable for given fuel.
	In combined grinding and drying with intermediate storage; discharge of vapors or conveying air a) directly into the atmosphere or into the stack without passing through separator; b) into the combustion chamber beyond the combustion zone; c) of larger combustion dust amounts into the primary flue-gas dust separator (interference with optimum precipitation action through introduction of dust not suitable for setting of separator; for this reason, b) may also be unfavorable).	In combined grinding and drying with intermediate storage; discharge of vapors or conveying air a) only through special electrostatic precipitators or non-combustible cloth filters when directly into the atmosphere or into the stack; b) or by combustion with the other combustion dust (if the moisture content of the vapors permits this).

(continued)

(Continuation of Table 2)

Point of Origin	In regard to the formation of fly-ash, the conditions listed below act:	
	Increasing	Reducing
Burner and combustion Fig. 2 ③	Disintegration of dust and conveying air in supply lines and burners.	Uniform easily adjustable distribution of fuel to individual burners.
	Unfavorable position of burner and flame in combustion chamber.	Favorable position of burner and direction of jet of the dust flame.
	Inadequate air supply, inadequate relative velocity between fuel dust and air stream. Inadequate preheating of combustion air. Incorrect air supply during variation of load.	Correct amounts of air and good turbulence of dust at all load stages. Velocity of secondary air not less than twice as great as velocity of primary air. High air temperature. Complete combustion of all solid and gaseous fuel.
	Inadequate combustion control; formation of cinders.	Highly effective combustion regulation and control.
	Fly-ash recirculation increases raw-gas dust content by definition and consequently load on dust separators. Unfavorable admission and velocity of fly-ash recirculation.	Furnace operation with maximum combustion so that fly-ash recirculation can be prevented.
Combustion chamber Fig. 2 ④	Inadequate height of combustion chamber, unfavorable relation of combustion-chamber volume to radiation-heating surfaces (poor combustion conditions through incorrect temperature relations at given flame positions; excessive cooling of flame, clinker deposits, formation of cinders).	Correct arrangement of combustion chamber and radiation chamber and radiation surfaces in relation to height and volume. Favorable discharge conditions for combustion-chamber ash.

(continued)

(continuation of Table 2)

Point of Origin	In regard to the formation of fly-ash, the conditions listed below act:	
	Increasing	Reducing
	Aerodynamically unfavorable form of combustion chamber (unfavorable air supply to fuel particles, inadequate turbulence possibilities). Unfavorable flame position and jet direction.	Aerodynamically correct design of necessary flow restrictions of combustion chamber.
Secondary heating surfaces and fly-ash collector, Fig. 2 ⑤	Unfavorable flow conditions. Inadequate fly-ash collectors. Aspiration of extraneous air when discharging fly-ash (fly-ash already precipitated may be entrained here). Failure to empty fly-ash collectors at proper time.	Dust precipitation by baffles, bends and changes in cross section. Large fly-ash collectors with strongly sloping sliding surfaces. High-grade trap closure for discharge of fly-ash.
	Dust clouds due to activation of soot-blower and ball-rain installations.	Soot-blowing and ball-rain at low load whenever possible.
Separator Fig. 2 ⑥	Cf. Section 2.21, 2.221, 2.222.	

2.2 Dust Removal in Dust Removal Installations:

For the precipitation of dust from flue gases of steam-generator installations, in general only centrifugal (cyclone) separators or electrostatic precipitators are suitable.

High efficiency rates can be attained with cyclones only for coarse dust. For dust with a high share of grains below 10 μ (about 50% smaller than 10 μ), electrostatic precipitators are better. On the other hand, the latter are more sensitive to overload on the gas side and to dust with particularly high electrical resistance.

Under the present status of dust technics, it should always be possible to attain guaranteed performances -- except in rare cases -- when planning carefully. The measurement tolerances inherent in the measurement method utilized should be taken into account.

Knowledge of the following data is important for the selection of the type of separator:

a) Type of construction and capacity of steam generator and furnace installation, installation with or without fly-ash recirculation, rate of ash fusion;

b) Characteristics of fuel (volatile components, ash content, ash characteristics);

c) Amount, grain classification and characteristics of raw-gas dust;

d) Available space for dust separator (6);

e) Stack height and discharge conditions (gas temperature and velocity);

f) Permissible emission.

Points a, b, c influence the volume and dust content of raw gas; point f depends among others on conditions in the vicinity, orographic and meteorological factors, prior loads and on point e (Cf. Section 3).

The design of the dust separator and/or its over-all efficiency rate is not exclusively decisive for the rate of emission. In one and the same dust separator and/or at the same efficiency rate, emission from the stack will reach higher values when the raw-gas dust content increases. In large installations and with a high-ash content of the coal, it may therefore become difficult to reduce emission from the stack, through selection of a high grade separator, to the desired degree whereas, at a low raw-gas dust content, adequately low emission may already be attained by utilization of a simple dust separator. The raw-gas dust content is especially influenced by the data listed under points a and b. For the selection of the type of separator, the points a, b, c are therefore particularly important.

Measurement of dust content in raw and purified gas should be carried out according to VDI Specifications No. 2066 (7, 8), and suitable measurement distances and instruments taps should be provided already in the design of the installation, together with early agreement on the measurement of amount and analysis of dust (blast sorting, sedimentation analysis, etc.) (14).

In order to prevent later discussion, it is recommended to settle already during the planning of new installations all questions important for dust removal from flue gases between the future operators, suppliers and inspection services. This includes, in addition to an unmistakable wording of the agreement on the guaranteed rate of dust precipitation, also a clear understanding of the prerequisites on which the guaranty is based. The agreed guaranty must be metrologically demonstrable in each case (14).

The instructions of the supplier of the dust-remover installation must be observed. The separator must be properly controlled and maintained in operation (Cf. pointers in Section 2.22 and the "Specifications on Placing Orders for Dust Removal Installations" of the Association of Steam Boiler Owners in Essen; 14).

2.21 Efficiency Rates

The following table contains efficiency rates obtained, under the present status of technology, from acceptance-inspection measurement of new installations.

In view of the inevitable drop in efficiency rate which experience shows to occur under operational conditions even with proper maintenance, the values listed in Table 3 can be valid only for the conditions on which the performance guaranty of a new installation is customarily based (absence of dirt, wear, etc.). The values of the table are therefore not applicable for the evaluation of dust emission in continuous operation (Cf. Sec. 3). The drop of the efficiency rate in operation as contrasted to the performance guaranty depends on structural and especially operational factors. It should be evaluated with great care during the planning of new installations in order to provide for an adequate interval of time between overhauls of the flue-gas purification installation in operation.

Table 3

Guarantied Efficiency Rates of New Separators

The following values were obtained under favorable conditions, e.g. during inspection acceptance. The high values listed in the table will therefore not be attained in all cases. In special cases, installations have been constructed in which these values have been exceeded.

Type of Separator	Efficiency Rate * %	Draft required mm H_2O	Range of Utilisation
Centrifugal (multicyclones)	Up to 90	50-100	Special case; for dust with low share of grains smaller than 10 µ.
Electrostatic	Up to 98.5	5-15	Normal case
Combined centrifugal and electrostatic.	Up to 98.5	65-100	In special cases with particularly high raw-gas dust content, wide difference in classification and high share of cinders.

* Depends largely on type of dust, content of dust, fineness of dust, shape of grain, gas and operational factors. The efficiency rate alone does not give any indication on the prevention of emission.

2.22 Influence on Efficiency Rate of Separators:

2.221 Mechanical Dust Separators:

Table 4

For operational efficiency, conditions listed below are:	
Unfavorable	Favorable
High share of fine grains in raw-gas dust (Cf. Fig. 1).	Design of separator adapted to given dust classification and characteristics.
Non-uniform loading of several parallel cyclones.	Uniform distribution of flue gases to several parallel aggregates and proper air-flow design of raw gas ducts.
Inadequate adjustability of separator. When adjustable, incorrect adjustment of load.	Shut-down of one or more aggregates under partial load.
Internal leakage due to wear, bypasses between individual cyclone or separator cells.	Proper maintenance and frequent inspection of parts subject to wear and suitable lining when necessary.
Clogging of cells and dust discharge traps of individual cyclone and separator cells. Leaking valves and traps, especially of dust-discharge devices.	Prevention of temperature drop below dew point. Continuous control of measurable operating data of separators, e.g., pressure drop and energy consumption (changes in values generally indicate defects and errors).
Wrong dimensions of separator (efficiency rate depends on flue-gas throughput).	Correct dimensions of separator for normal steam-generator load.

2.222 Electrostatic Precipitators:

Table 5

For operational efficiency, conditions listed below are: Unfavorable	Favorable
Operational deviations from design data of separator, e.g. raw-gas volume and velocity (extraneous air, overloading), temperature, moisture, dust content, grain classification, and characteristics of dust.	Low gas velocity and adequate interval of passage through separator. Strict compliance with operating instruction.
Electrical resistance of dust too high or too low due to changes in fuel, ash or grinding, especially poor or especially good combustion, flue gas too dry, unfavorable temperature and moisture. (Especially good combustion can result in excessive combustion chamber temperature, ash vaporisation, high share of ultrafine particles and solid dust deposition on electrodes).	Favorable content of incombustibles (5-15%). Electrical resistance of dust around 10^4 to 10^{11} Ohm x cm, moist flue gas (humidifying of flue gas when necessary).
Inappropriate voltage for given characteristics of raw gas and/or dust (frequent sparking, short circuits or switch-opening). Unsuitable deposition and spray electrodes.	Maximum possible voltage through full-automatic regulation. Circuit of flue-gas flow most favorable for given type of dust and corresponding phasing of electrode voltage in the individual chambers (preionization when necessary). adequately designed high-voltage aggregates.
Non-uniform gas and dust flow, aerodynamically unfavorable structural members in dust chamber (deposition of dust on girders, etc.) Non-uniform distribution of dust in flue-gas flow.	Uniform velocity and distribution of dust over the entire cross-section of electrofilter using baffles or perforated plates for improvement of flow when necessary. Prevention of dust accumulation in stagnant angles at baffles and electrodes.

(continued)

(continuation of Table 5)

For operational efficiency, conditions listed below are:	
Unfavorable	Favorable
Inappropriate vibration (e.g. simultaneous vibration of all plates, vibration intervals too long or too short), fouled deposition electrodes (inactivation of electrical field and occurrence of clogging of entire ducts).	Proper operation and maintenance of filter-cleaning devices (vibrators, beater devices, etc.) and careful inspection of electrodes, cleaning interior of separator during boiler shutdown, when necessary.
Non-uniform or inappropriate ash removal, admission of extraneous air during ash removal, leaking ash traps. Turbulence above already deposited dust.	Regular and/or automatic ash removal; well sealed ash discharge devices and proper inspection and maintenance of the latter; prevention of admission of extraneous air (e.g. leaking valves of bypass ducts).
Poor inspection and maintenance of overall installation. Non-uniform distances of electrodes. Damage to insulators.	Systematic supervision of important aggregates and scheduled overhaul, continuous control of measurable operating data (changes in values generally indicate defects and errors.

2.3 Stacks:

Determination of the necessary stack height and discharge cross section should be made by utilizing:

the indications in Sec. 3, Restriction of Dust Emission;
VDI Specifications No. 2299 (in preparation), Restriction of Sulphur-Dioxide Emission;
VDI Specifications No. 2289 (in preparation), Determination of Minimum Stack Height.

In addition to creating draft, an essential purpose of the stack is to discharge gas and dust as high as possible above the surface of the ground and to reduce the concentration of substances foreign-to-air above the ground and the deposition of dust on the ground by the resulting dilution of the gases with atmospheric air (9, 10, 11, 12).

This can be accomplished by:

high stacks;
utilization of the t'ermic lift of the smoke streamer;
high discharge velocity of flue gas at the top of the stack.

At the same temperature and velocity of flue gas, greater thermic lift may be expected from one stack (with large diameter) than by distributing the same volume of flue gas over several stacks of smaller diameter. For this reason, the discharge of the flue gases from several steam generators by one chimney with a large diameter may be more advantageous than several stacks with correspondingly smaller diameters. Any decision in regard to this must, however, take into account partial load factors.

3. Restriction of Dust Emission

All newly constructed steam-generating installations fired with ash-containing fuels must be equipped with dust-removal installations which should be designed — unless Sec. 3.1 makes higher demands — according to the conditions for restriction of emission in Sec. 3.2 and in the diagram "Restriction of Dust Emission in Newly Constructed Installations". All such dust-removal installations must correspond to the most recent technical findings (15, 16).

3.1 Restriction of Emission on the Basis of Deposition:

The emission of dust from an installation should be restricted on the basis of the permissible amounts of deposition in the vicinity and by the conditions of distribution given through the location and type of construction of the plant (stack height, adjacent emitters, orographic position, etc.). This should take into account already existing prior load factors and the permissible dust level of the area (this manner of determining the restriction of emission by deposition takes into account the natural laws of the relation between emission, distribution and deposition; Cf. VDI Specifications No. 2289 on Determination of Minimum Stack Height).

3.2 Restriction of Emission on the Basis of Technical Factors:

Unless the conditions in Sec. 3.1 make higher demands on the degree of purity of the flue gases, a technically and economically defensible installation corresponding to the type and capacity of the main installation should be provided for the reduction of dust content in flue gas.

In the diagram "Restriction of Dust Emission in Newly Constructed Installations", the maximum permissible dust emission from a new installation is represented as a function of the total amount of ash produced in the furnace installations of the overall installation. For the determination of the amount of ash produced by the overall installation, calculations should be based on maximum continuous output of the steam-generating installation. The permissible volume of dust emission for the new installation results from the percentage indicated in the ordinate as a function of the amount of ash produced in the new installation.

The limit curve of the diagram for maximum permissible dust emission in continuous operation is applicable to normal and technically controlable operating conditions. If special difficulties for the construction of the dust-removal installations result from the type of fuel or conditions of combustion, minor increases of the permissible emission in continuous operation may be authorised after careful examination of all technical possibilities. For an ash total in excess of 100 ton/hr, a special authorisation should be procured in each case on maximum permissible emission. A transgression of the established maximum emission values in operation can be accepted only in exceptional cases where subsequent operational factors could not be anticipated during planning and if the dust removal installation was designed according to the most recent technical findings.

3.21 Instructions for Utilisation of Diagram:

The regulations on restriction do not indicate the degree of dust separation to be selected but the maximum permissible volume of dust emission (fly-ash including cinders). The decision on the degree of dust separation can be made in each case only in consideration of the dust deposition in the boiler (ash fusion) and the permissible dust emission (it is recommended to include future plans for enlargement in the calculations).

The letter symbols in the diagram and/or the examples below (13) represent:

A_{m_g} = (Abscissa) = the total ash from furnace installations of the overall installation in ton/hr at maximum continuous output of the boilers.

A_{m_n} = The total ash from the furnace installation of the new installation in ton/hr under maximum continuous output of the boiler.

(In the determination of the A_m-values, the maximum average 28-day value of the ash content of the fuel to be expected should be used.)

σ_s = (Ordinate) = maximum permissible dust emission from new installation in continuous operation as % of the total ash A_{B_n} of the new installation under maximum continuous output of the boiler.

β = Degree of ash fusion of the furnace installation.

An extrapolation of the limit curve for σ_s to the left or right beyond the range of the diagram should not be made. Special authorisation should be procured for A_{B_g} = 100 ton/hr. For installations below A_{B_g} = 0.2 ton/hr, VDI Specifications No. 2300 "Restricting Dust Emission from Boiler Installations, Capacity 10 ton/hr and Less" is applicable.

The air pollution to be anticipated is decisively influenced by the dust emission from the overall installation. The diagram therefore contains as abscissa the total ash A_{B_g} of the overall installation. The overall installation consists of individual aggregates which are structurally related or may be considered as operational units. The overall installation may have one or more stacks.

The ordinate represents the stack discharge (σ_s) permissible for the new installation as % of the total ash from the new installation.

A new installation is considered to be a newly constructed installation either entirely new or an addition to an existing installation. If a new installation is constructed as an addition to an existing installation, then the existing installation together with the new installation is considered to be the overall installation.

The maximum permissible emission indicated in the diagram is valid for maximum continuous load in continuous operation during the authorised operating life of the installation. In connection with this, it should be recalled in particular that the effectiveness of dust separators drops after long-continued operation. In the determination of performance guaranties on the basis of the values for the restriction of emission, this should be taken into consideration accordingly (Cf. Sec. 2.21).

The lines in the diagram traced below an angle of 45° are guidelines for the minimum stack height to be employed. Stack height is here considered the height of the top of the stack above the ground.

The minimum stack height results from the intersection of the vertical of the respective A_{B_g}-value (abscissa) with the curve for the maximum permissible dust emission. Lesser stack heights require special

measures for dust removal. Stack heights lying above the line for the maximum permissible dust emission, i.e., greater stack heights, do not authorize calculation of higher dust emission values than correspond to the curve for the maximum permissible dust emission.

In consideration of the immediate vicinity, however, the top of the stack should be at least 1.7 times as high as the highest building in the vicinity of the stack (11, 12).

Above the 120-m line, i.e., for very large installations, special authorization should be procured for the minimum stack height.

Examples:

a) Existing Installation:

Steam production	300 ton/hr
a_f = 20% (in relation to delivery state)	
Total fuel	37.0 ton/hr
Total ash in fuel	7.4 ton/hr

b) New Installation:

Steam production	200 ton/hr
a_f = 20% (in relation to delivery state)	
Total fuel	24.7 ton/hr
Total ash in fuel A_{m_n}	4.94 ton/hr
Degree of ash fusion β = 10 - 20%	

c) Overall Installation:

Steam production	500 ton/hr
Total fuel	61.7 ton/hr
Ash total A_{m_g}	12.34 ton/hr

According to the diagram, this then results for the newly constructed part of the installation in A_{m_g} = 12.34 ton/hr according to the limit curve

$$\sigma_g = 3.68\%.$$

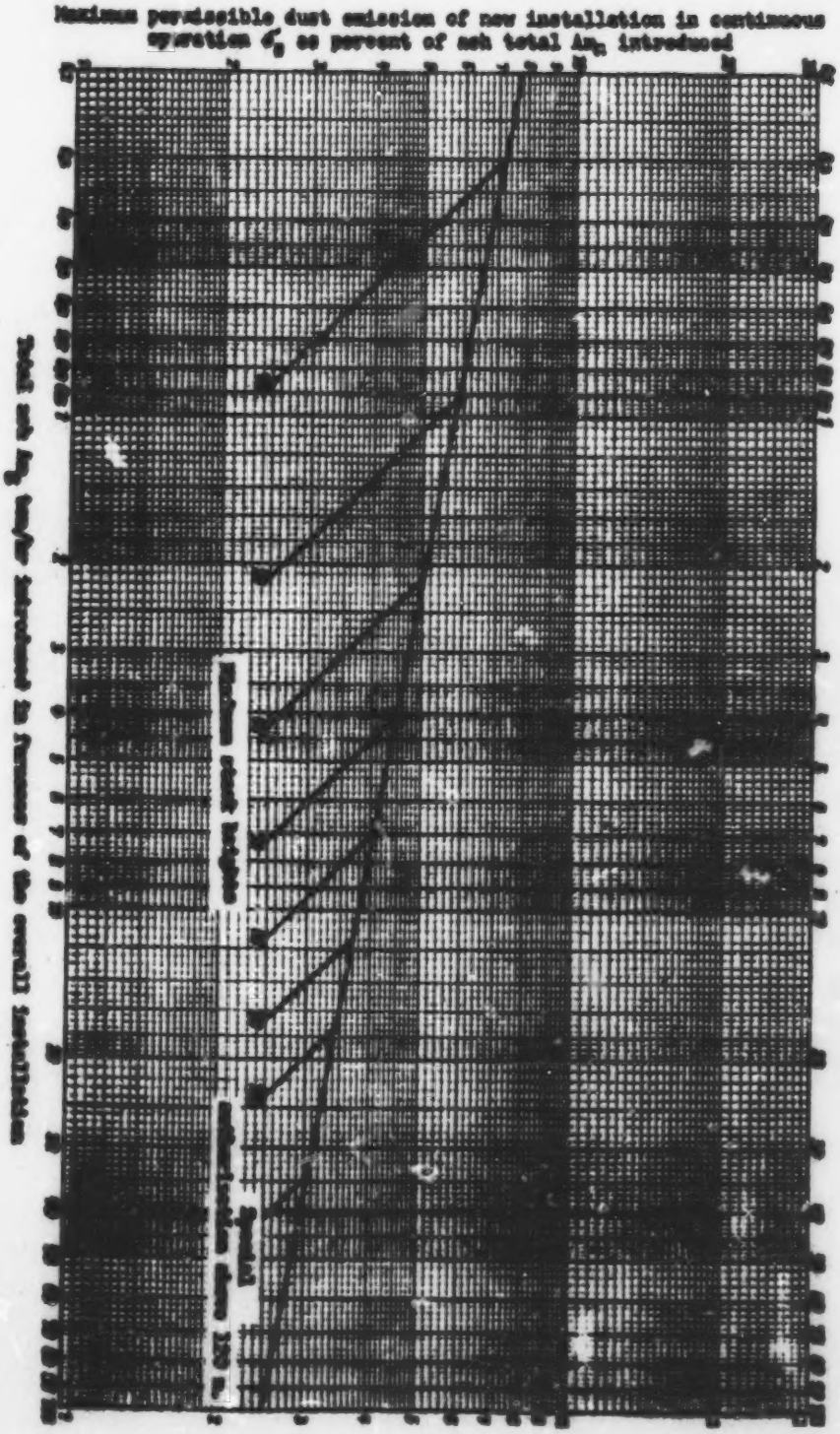
The required minimum stack height for A_{m_g} = 12.34 ton/hr (interpolated) amounts to H = 92 m.

This minimum height is sufficient only when a greater stack height is not required by Sec. 3.1 or in consideration of buildings in the vicinity (Cf. Sec. 3.21) or on the basis of the VDI Specifications on Sulphur-Dioxide Emission.

If unavoidable circumstances permit a stack height of only 85 m, dust emission may then only amount to σ_s = 2.85% (this reduction in stack height is obviously permissible also only if the condition listed in the previous paragraph has been fulfilled). Higher stacks than required by the diagram do not justify higher emission.

The values for σ_s determined from the above examples shall not be exceeded in continuous operation. The manner in which these emission values are obtained is left to the discretion of the designer of the steam-generating installation. He may make his selection among the possibilities which are offered to him by the design of the steam generator and of the furnace installation (ash fusion) on the one hand and by the selection of the dust separator for flue gases (degree of dust separation) on the other hand.

In view of the drop in the efficiency rate of the separator after long-continued operation already mentioned, a correspondingly higher value must be specified for the guaranteed efficiency rate when placing the order.


Maximum permissible dust emission of new installation in continuous operation G_g as percent of such total Δm_g introduced
Restriction of dust emission for highly burdened installations

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